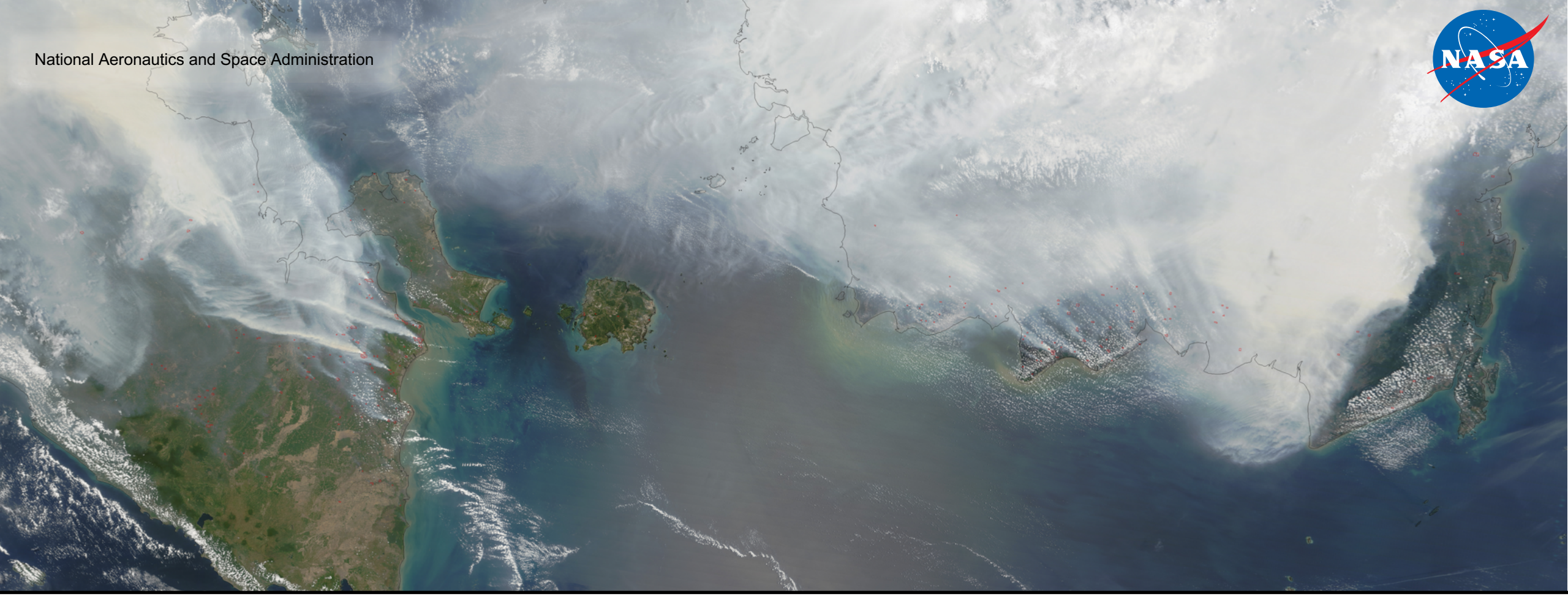
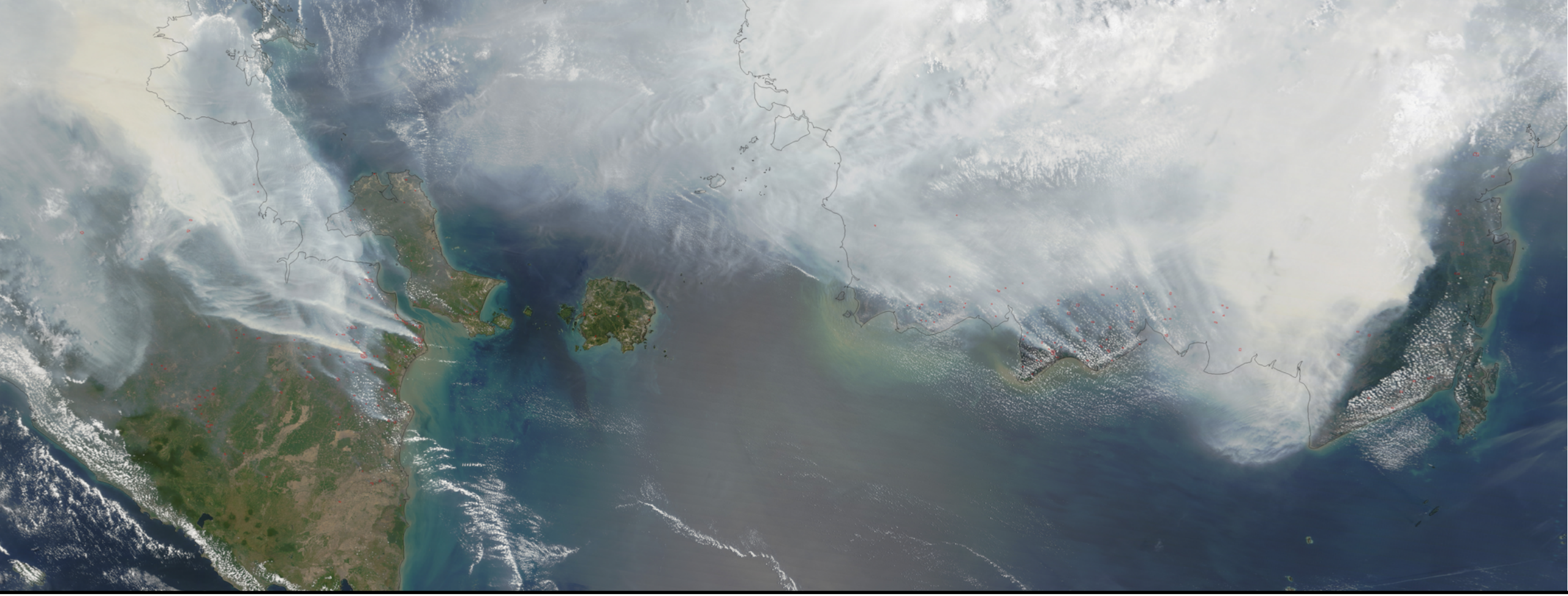
National Aeronautics and Space Administration



New and Upcoming Satellite Capabilities for Air Quality Monitoring

Melanie Follette-Cook, Pawan Gupta, and Bryan Duncan

NASA Remote Sensing for Air Quality Applications, March 20-23, 2018, Jakarta, Indonesia



VIIRS

Visible Infrared Imaging Radiometer (VIIRS)

A multi-wavelength imager like MODIS with similar wavelength bands

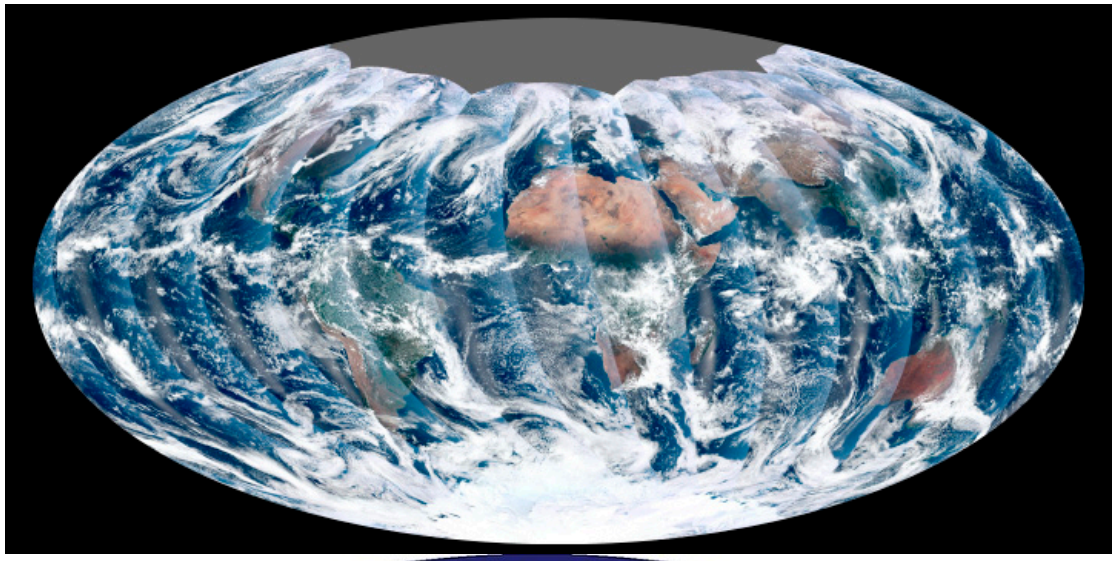
VIIRS is a continuous mission until 2038 - another VIIRS launched on JPSS-1in Nov 2017

	MODIS	VIIRS
Orbit Altitude	690 km	824 km
Equator Crossing Time	13:30 LT	13:30 LT
Granule Size	5 min	86 sec
Swath	2,330 km	3,000 km
Pixel Nadir	0.5 km	0.75 km
Pixel Edge	2 km	1.5 km

VIIRS and MODIS

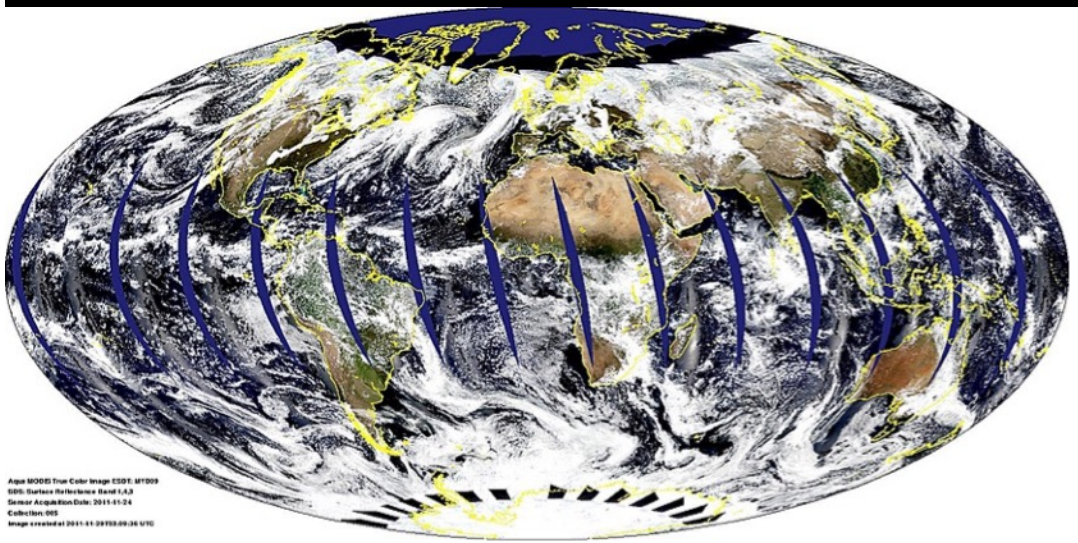
VIIRS

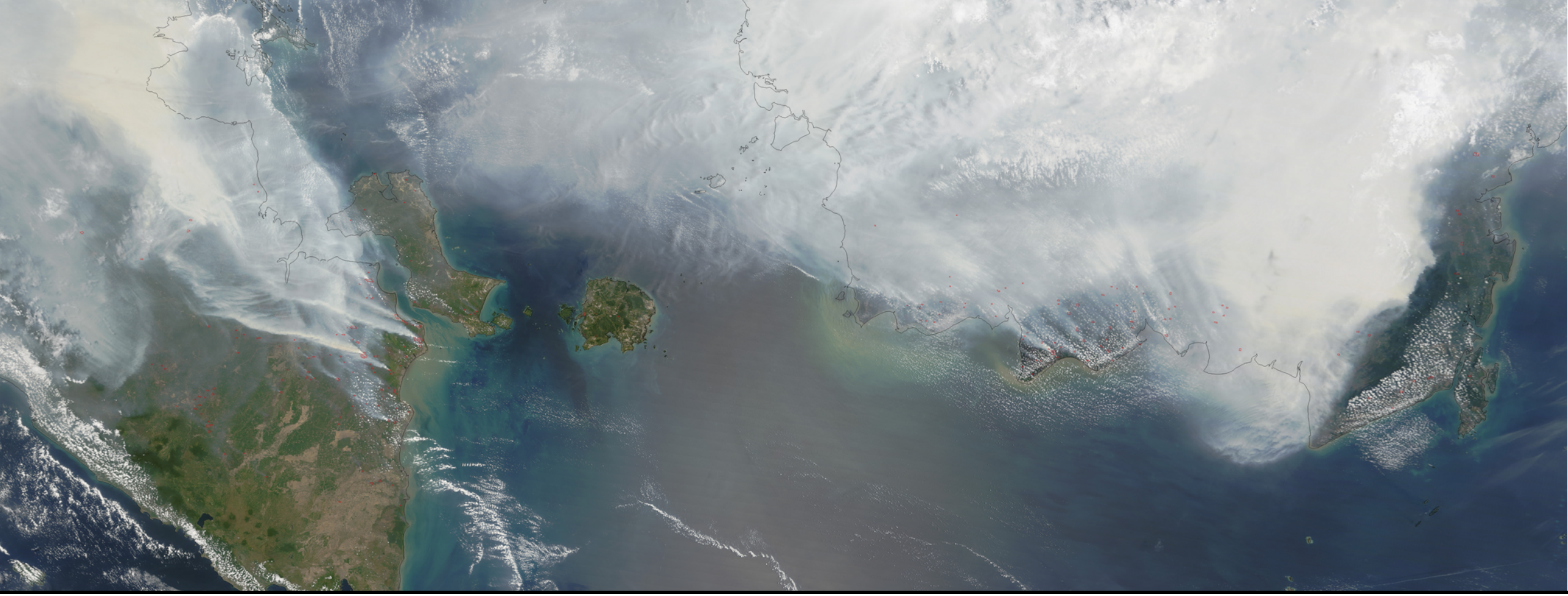
Nov 24, 2011



MODIS (Aqua)

Nov 24, 2011

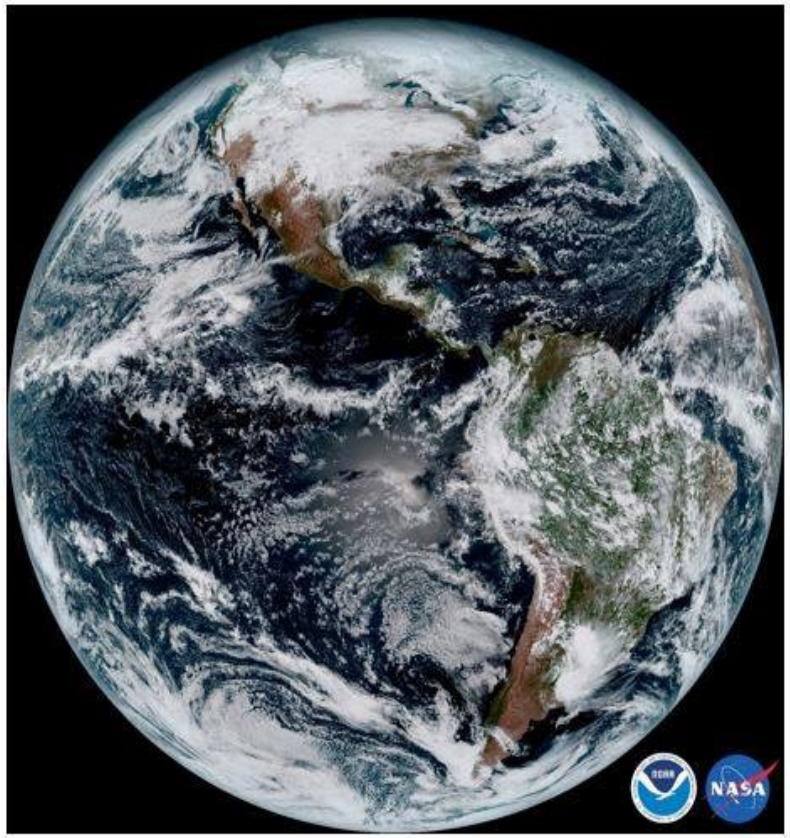




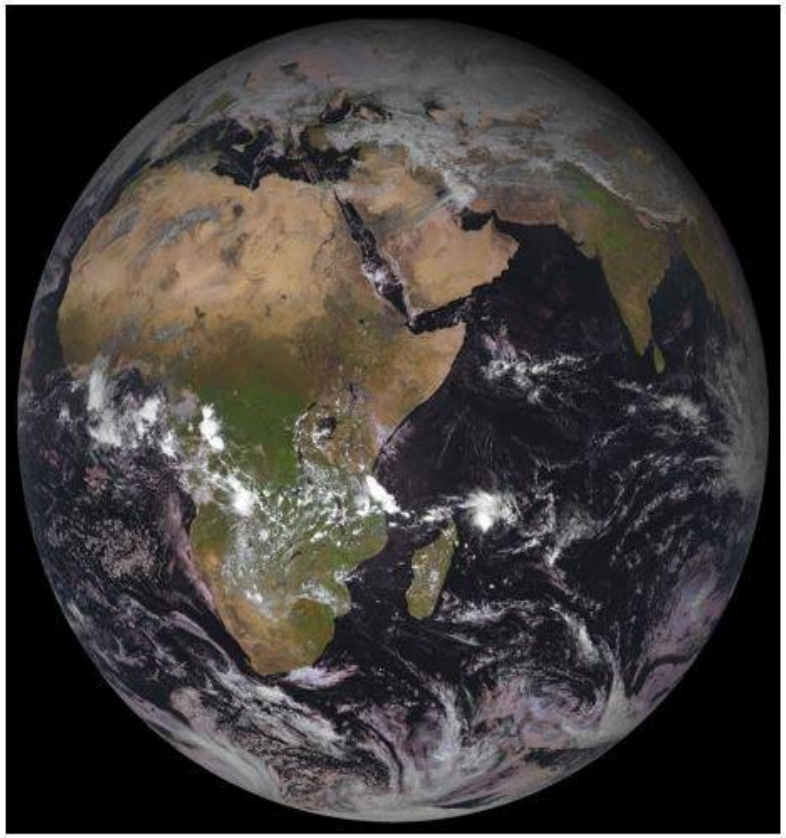
GOES-East & HIMAWARI-8

Breaking the Temporal Barrier

The beginning of a new era in satellite remote sensing of air quality



GOES-16



METEOSAT-8

HIMAWARI-9

HIMAWARI-8 Loop: Fire Smoke over Indonesia

October, 2015

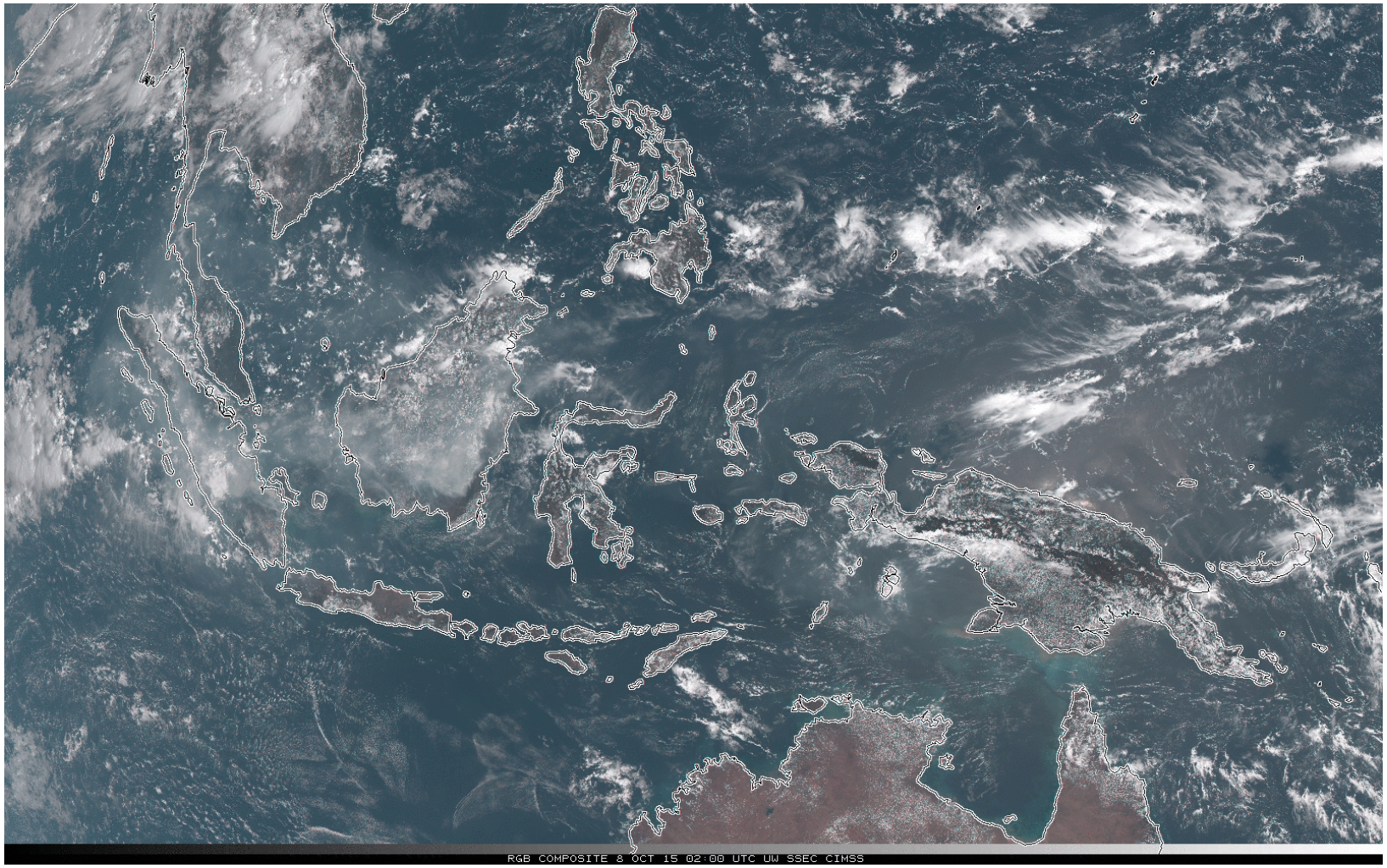
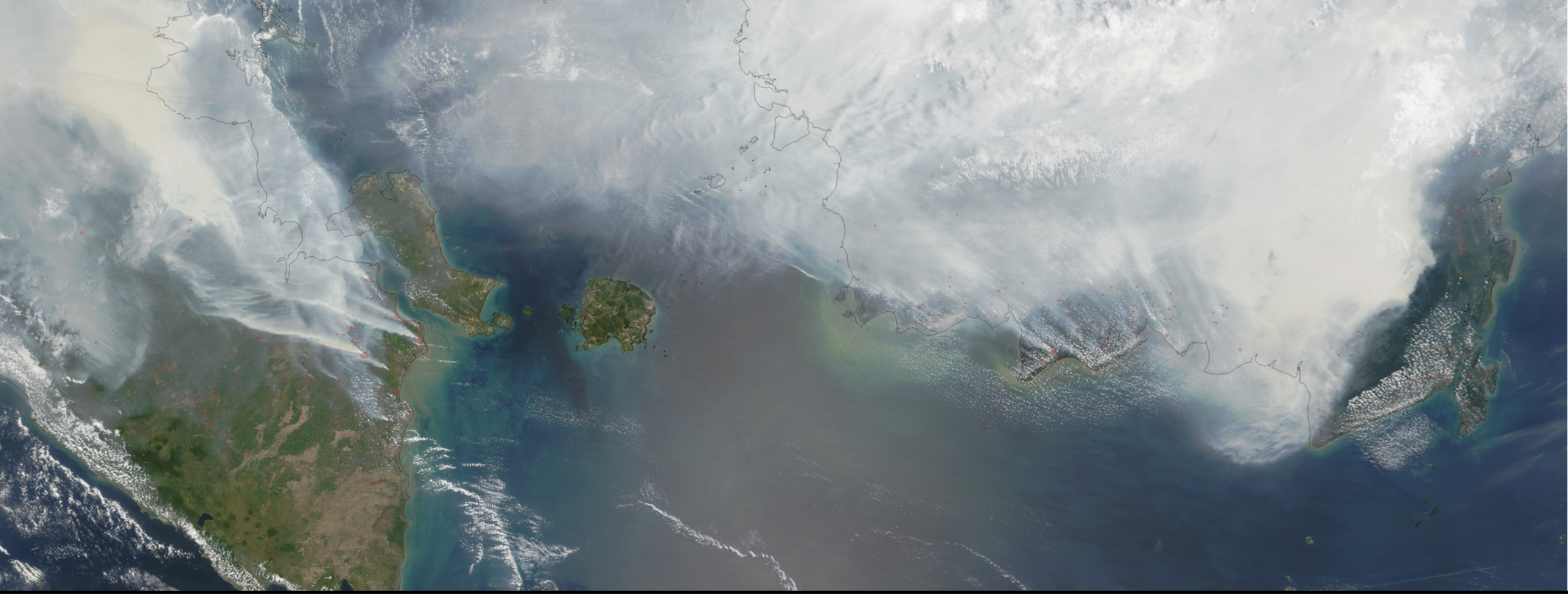


Image: CIMSS Satellite Blog: http://cimss.ssec.wisc.edu/goes/blog/archives/19897

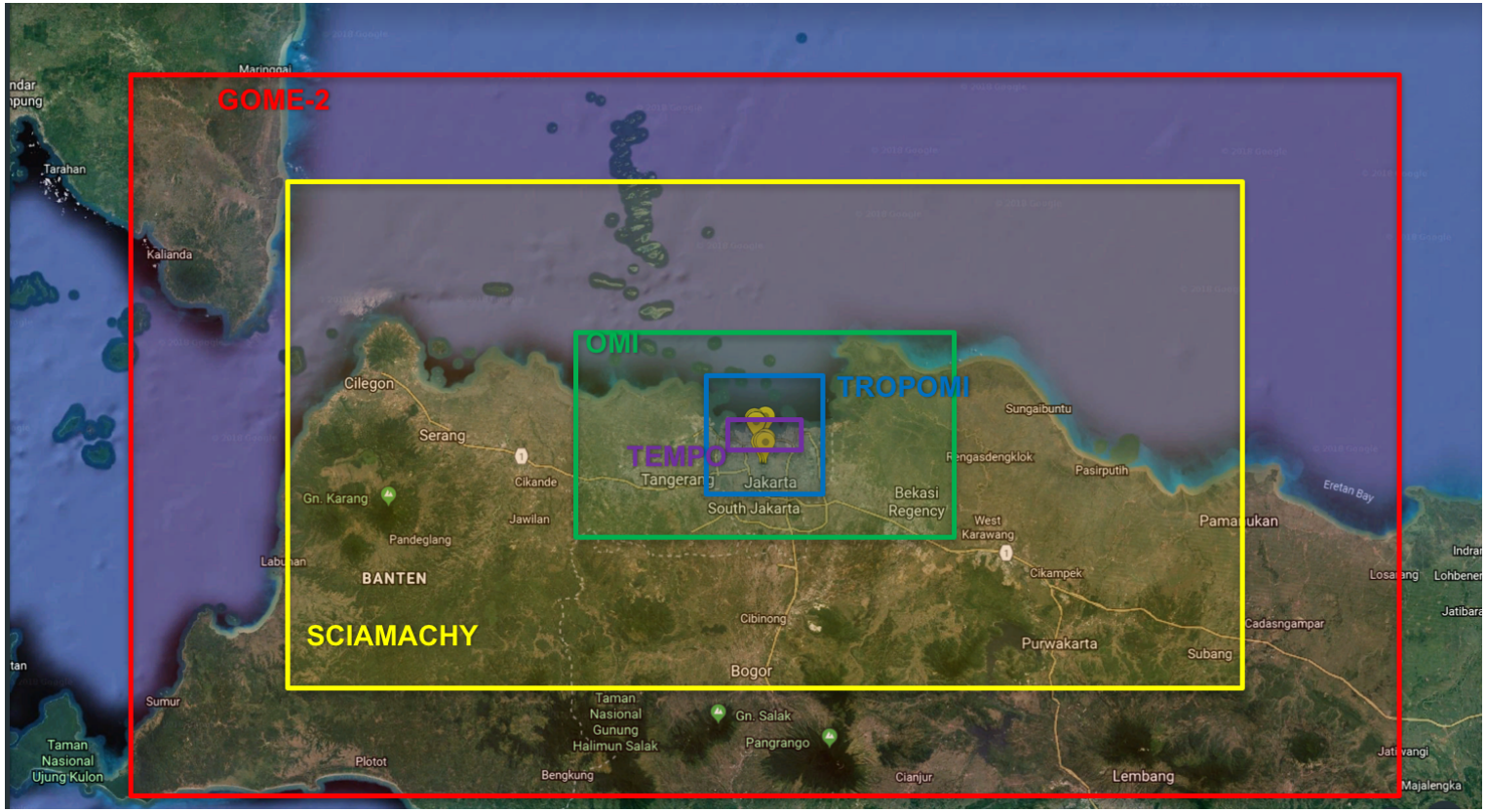


TROPOMI

TROPOspheric Monitoring Instrument (TROPOMI)

TROPOMI Highlights

- Launched on October 13 2017 by the European Space Agency
- Global Coverage
- Sub-urban spatial resolution (3.5 x 7 km^2)
- *1x/day*: NO_2, ozone (0-2 km vertical), aerosol, clouds, formaldehyde, glyoxal, SO_2, CO, methane

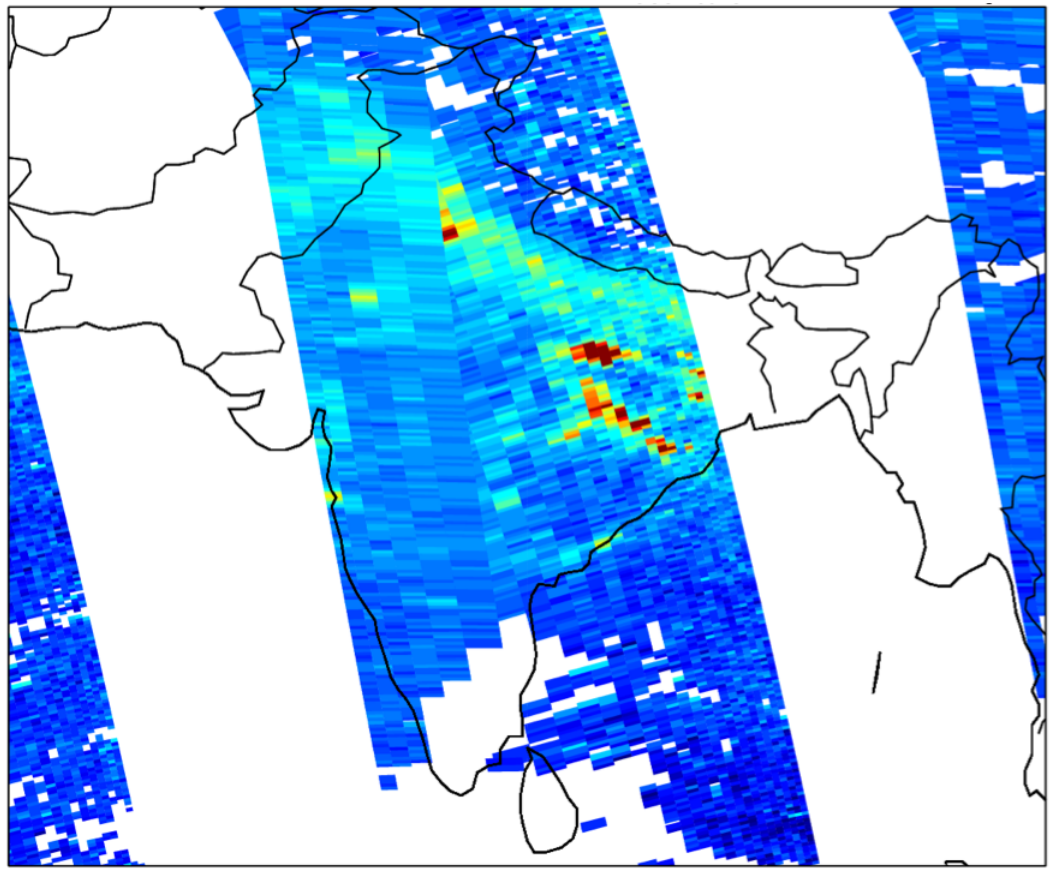


Slide Courtesy of TROPOMI Science Team

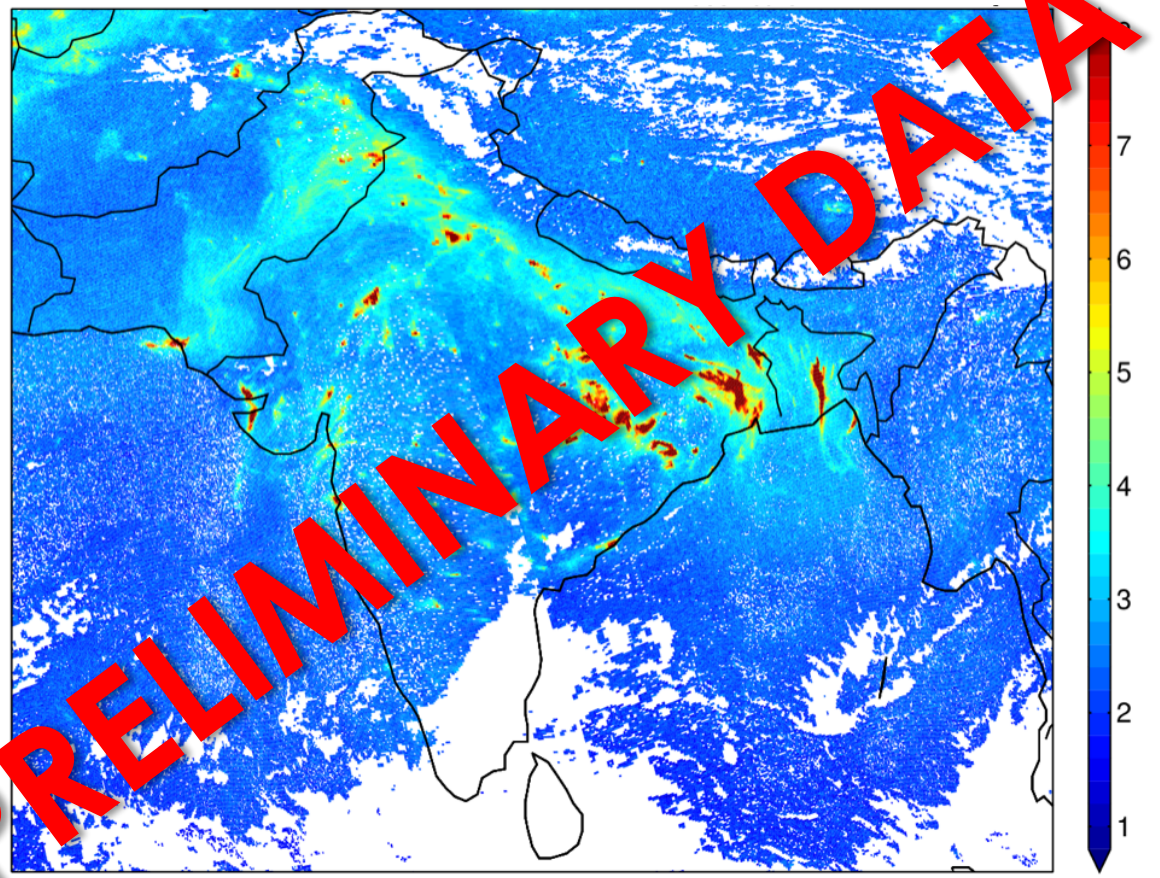
TROPOMI: Impact of Resolution

November 28, 2017

OMI NO_2 (Real Data)



TROPOMI NO_2 (Real Data)



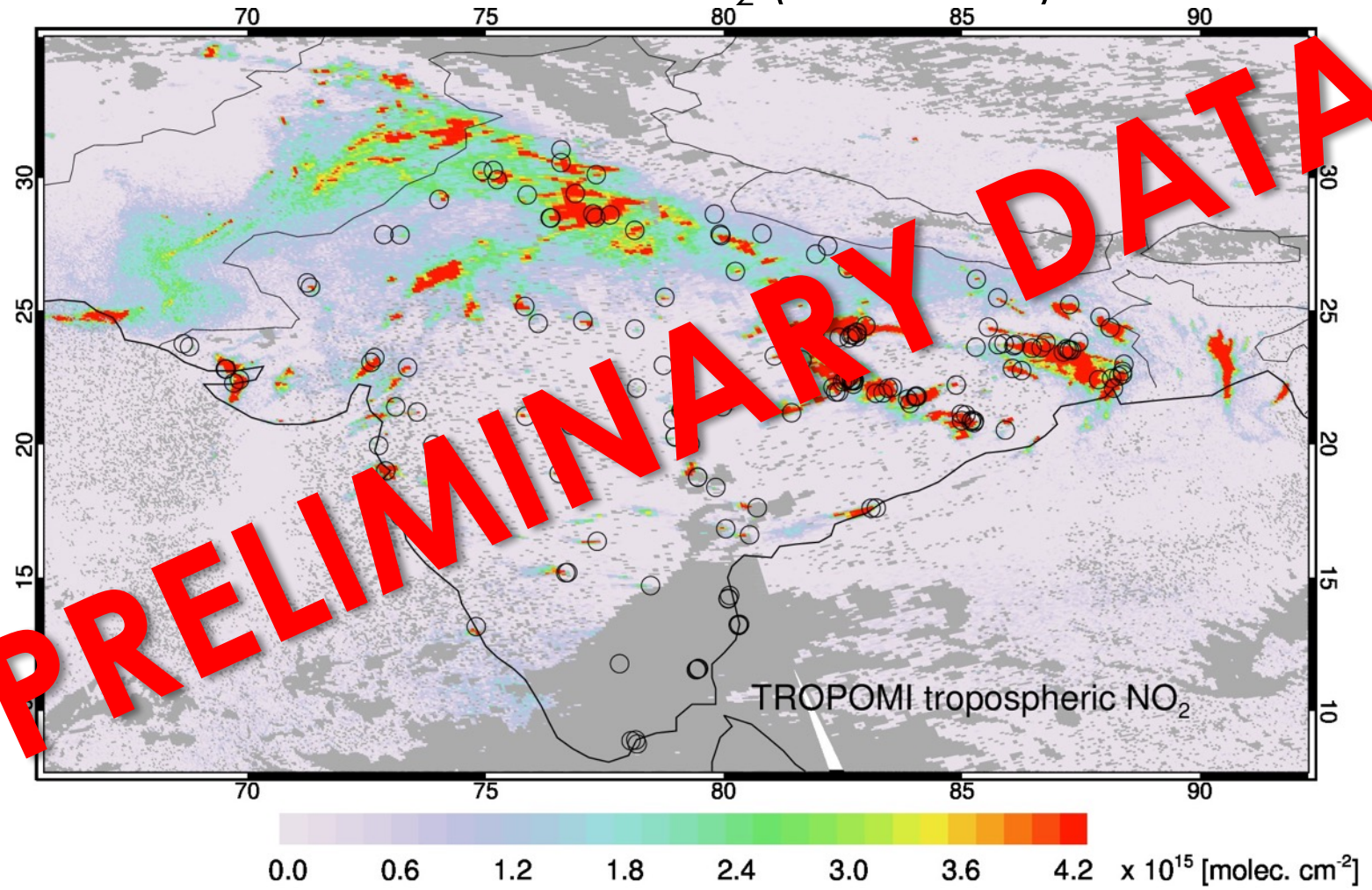
Spatial Resolution = 3.5 x 7.0 km^2

TROPOMI data courtesy of ESA

TROPOMI: Plume Detection

November 28, 2017

TROPOMI NO_2 (Real Data)



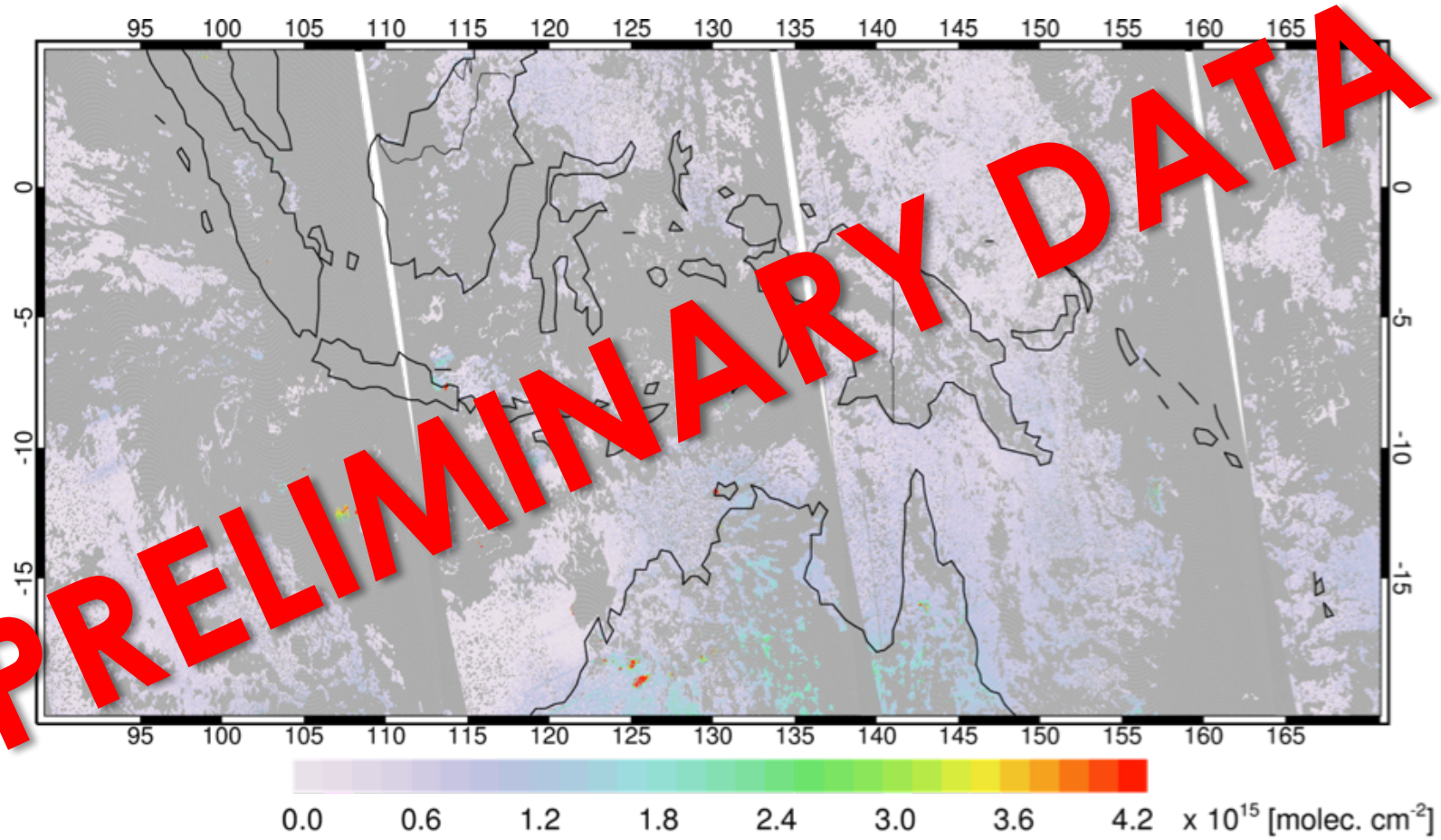
- Power Plants

TROPOMI data courtesy of ESA

TROPOMI: Too Cloudy

November 28, 2017

TROPOMI NO_2 (Real Data)

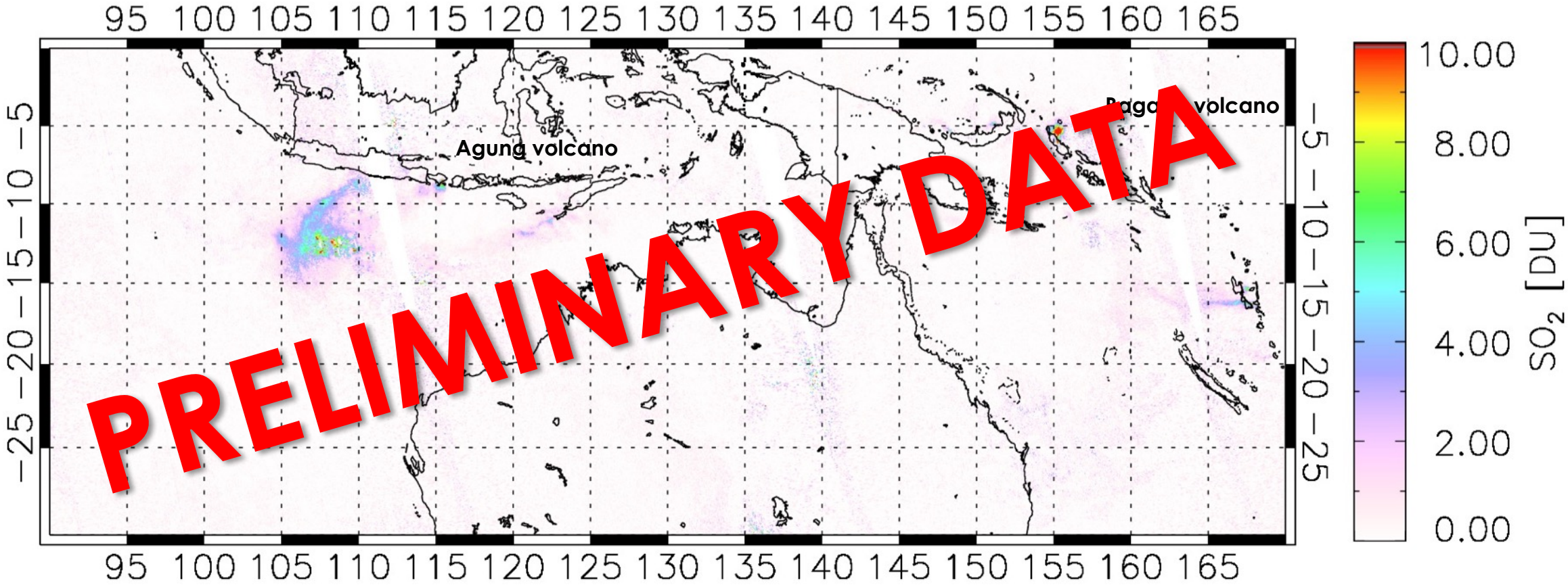


TROPOMI data courtesy of ESA

TROPOMI: Mount Agung Eruption

November 28, 2017

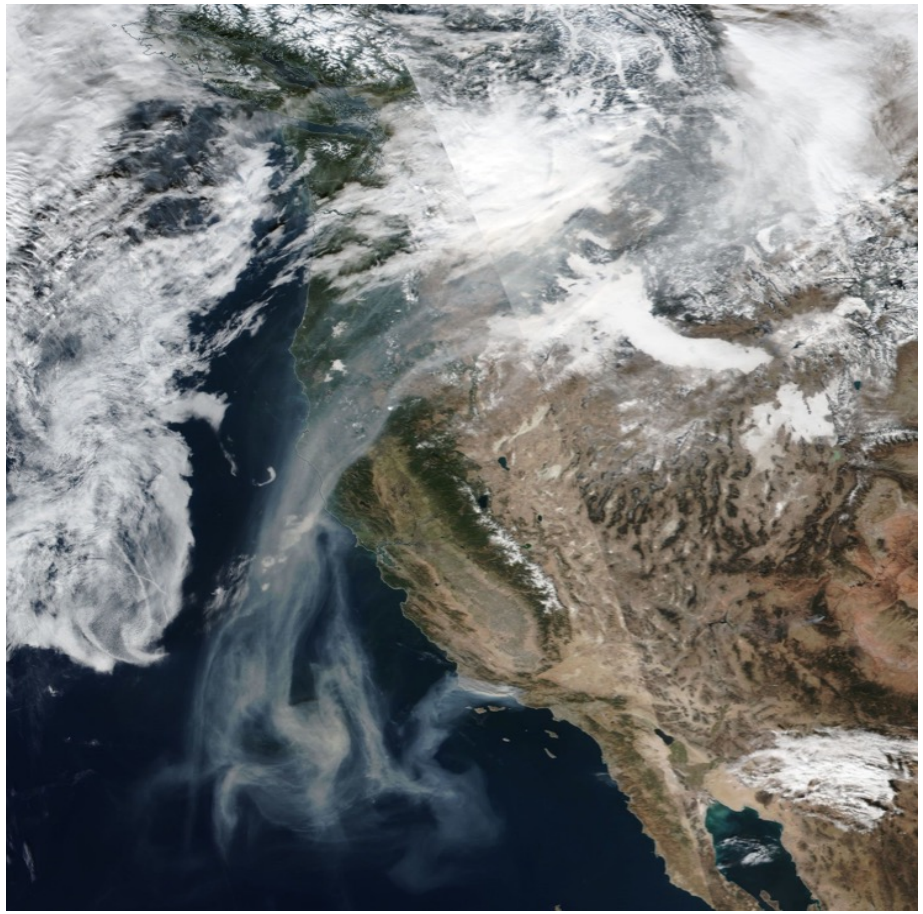
TROPOMI SO_2 (Real Data)



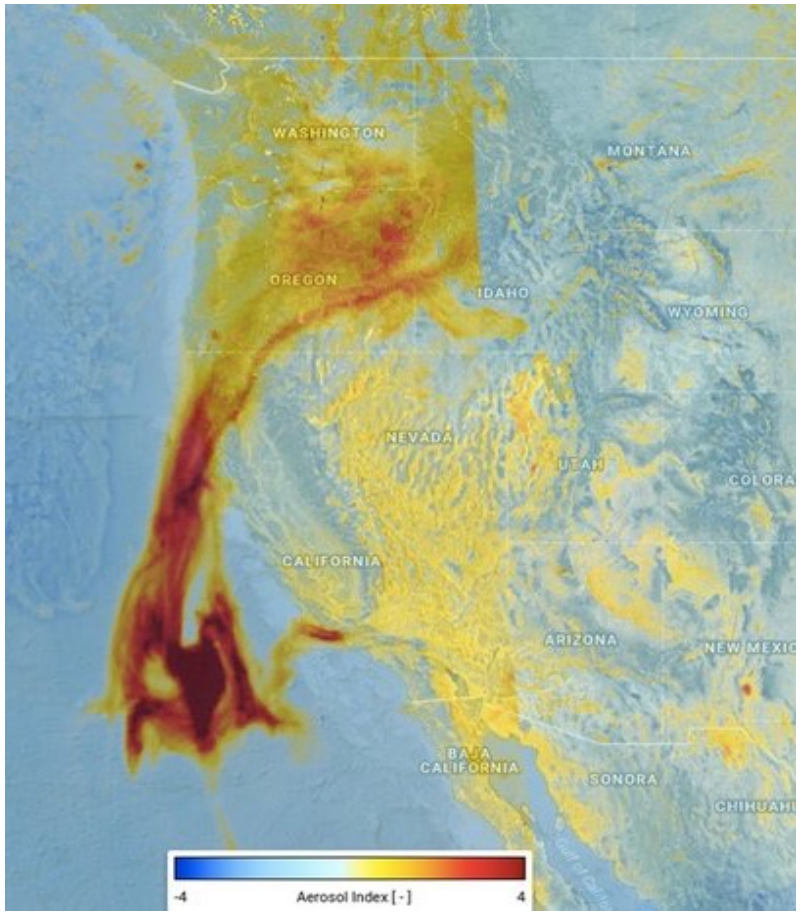
TROPOMI data courtesy of ESA

TROPOMI: California Fires - December 12, 2017

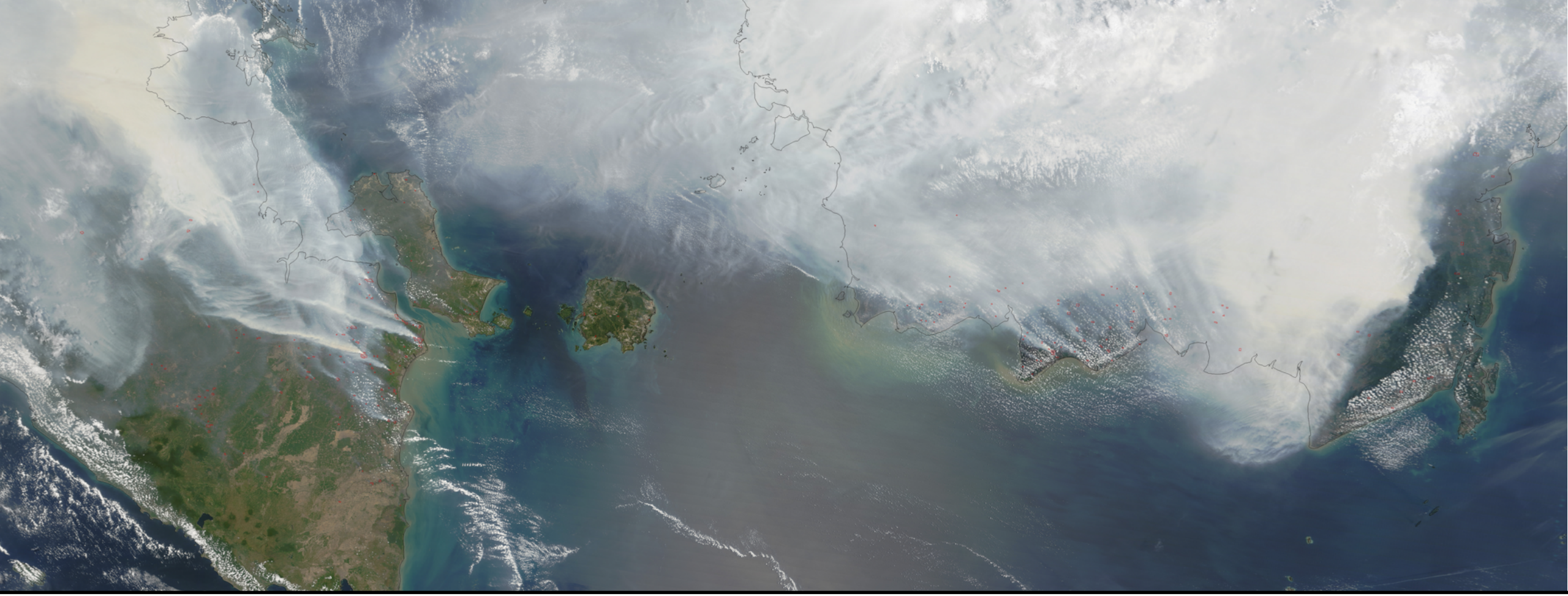
VIIRS



TROPOMI (real data)



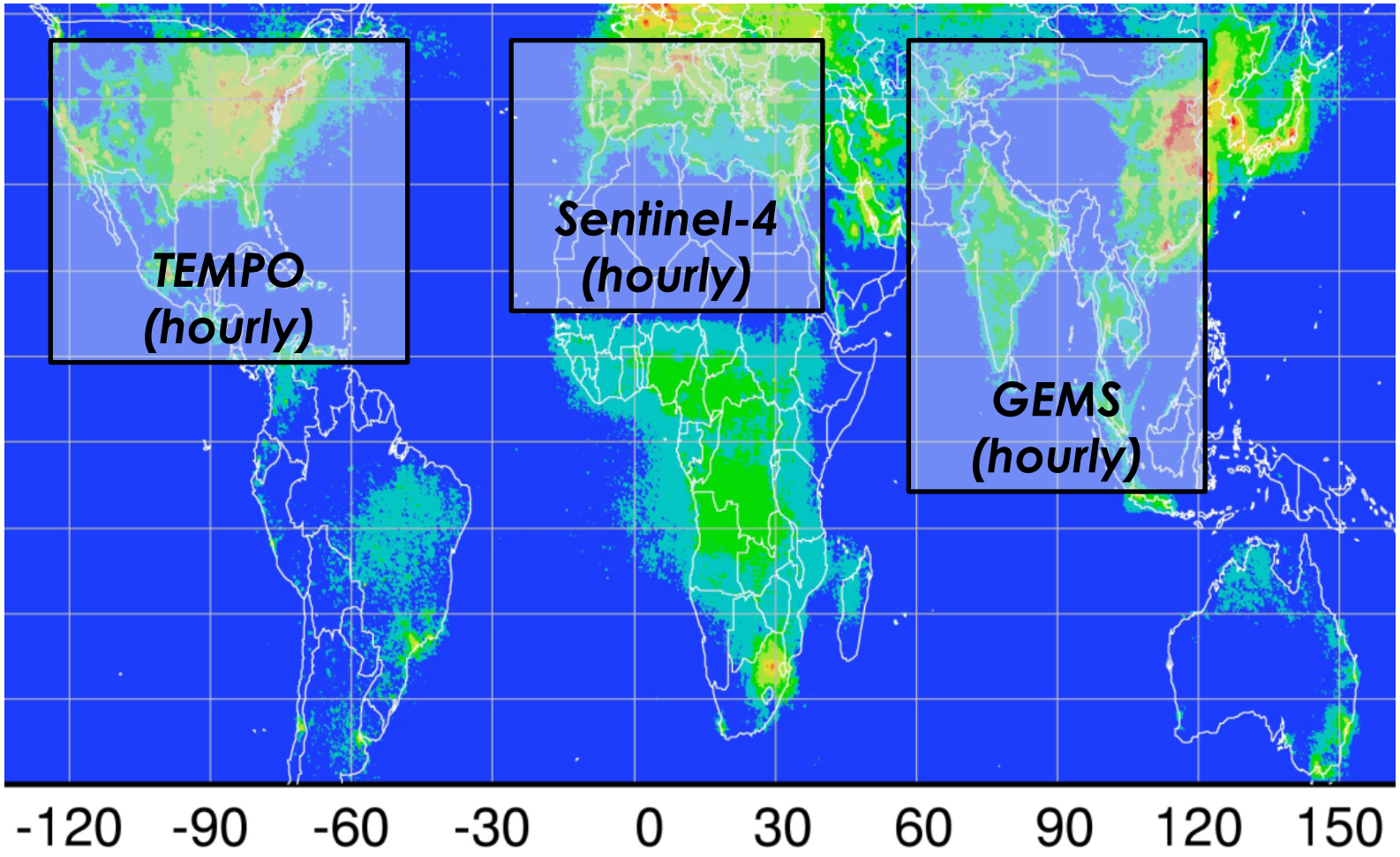
TROPOMI: https://www.esa.int/spaceinimages/Images/2017/12/Tracking_aerosols_from_California_s_fires



Future Satellite Capabilities for Air Quality Applications

Global Pollution Monitoring Constellation (2020s)

- Improved emissions, at common confidence levels, over industrialized Northern Hemisphere
- Improved air quality forecasts and assimilation systems
- Improved assessment, e.g., observations to support United Nations Convention on Long Range Transboundary Air Pollution



Image, courtesy of Jhoon Kim, Andreas Richter; text courtesy of K.Chance

GEMS: Geostationary Environment Monitoring Spectrometer

- Geostationary over East Asia, **not** including Java, southern Borneo, southern Sumatra
- High Temporal Resolution
  - 1 hr
- High Spatial Resolution
  - 5.0 x 15.0 km^2
- Spectral Range
  - 300-500 nm
- Data Products:
  - nitrogen dioxide, sulfur dioxide, formaldehyde, ozone and other aerosols
- Expected Launch: 2019

http://gems1.yonsei.ac.kr/

Sentinel-4

- Geostationary over Europe and North Africa
- High Temporal Resolution
  - 1 hr
- High Spatial Resolution
  - 8 x 8 km^2 over Europe
- Spectral Range
  - ultraviolet (305-400 nm), visible (400-500 nm) and near-infrared (750-775 nm)
- Data Products:
  - nitrogen dioxide, sulfur dioxide, formaldehyde, ozone and aerosol optical depth
- Expected Launch: 2021

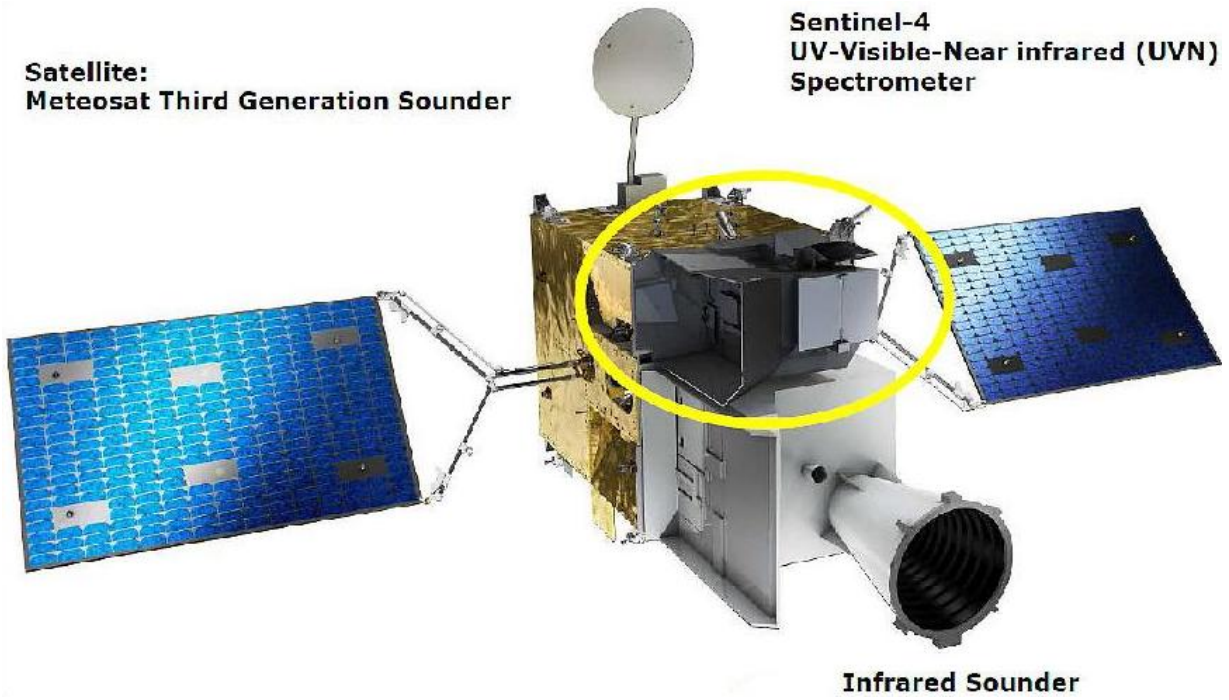
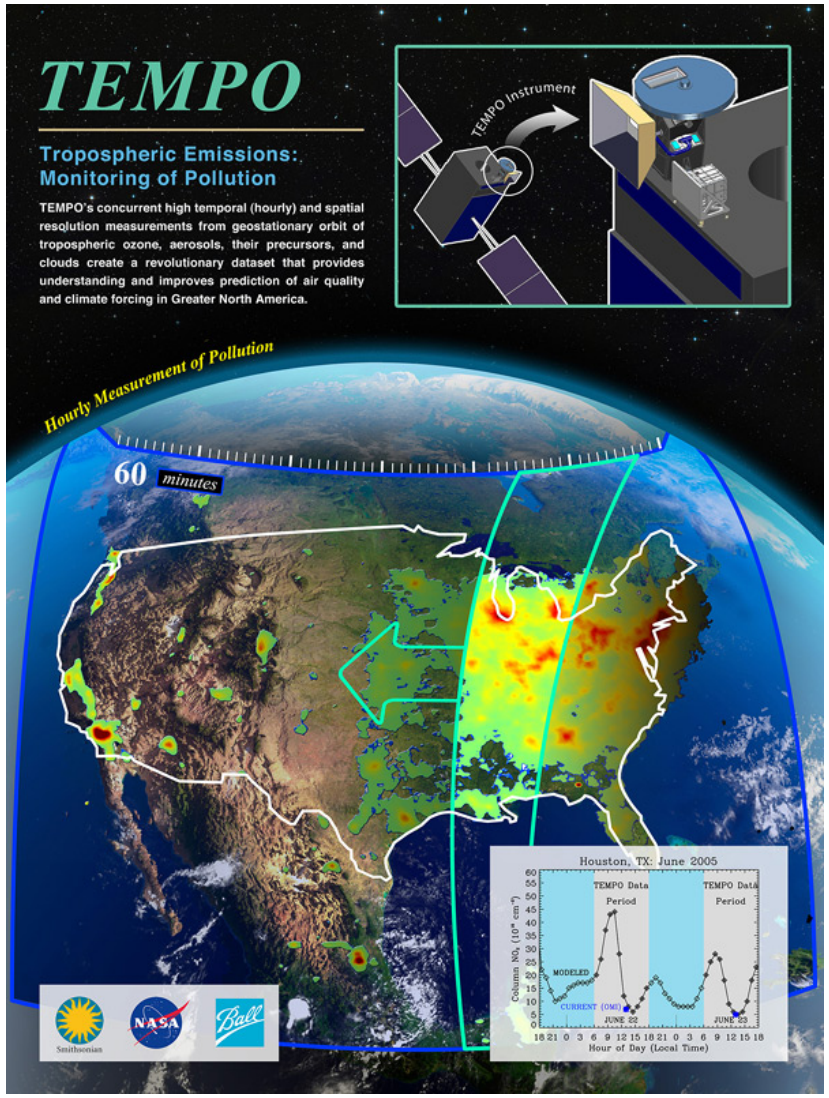


Image credit: ESA

TEMPO: Tropospheric Emissions: Monitoring of Air Pollution

- Geostationary over North America
- High Temporal Resolution
  - 1 hr
- High Spatial Resolution
  - 2.2 x 4.7 km^2
- Spectral Range
  - 290-740 nm
- Data Products:
  - O_3, NO_2, $C_2H_2O_2$, aerosols, cloud parameters, & UVB radiation
- Expected Launch: 2021



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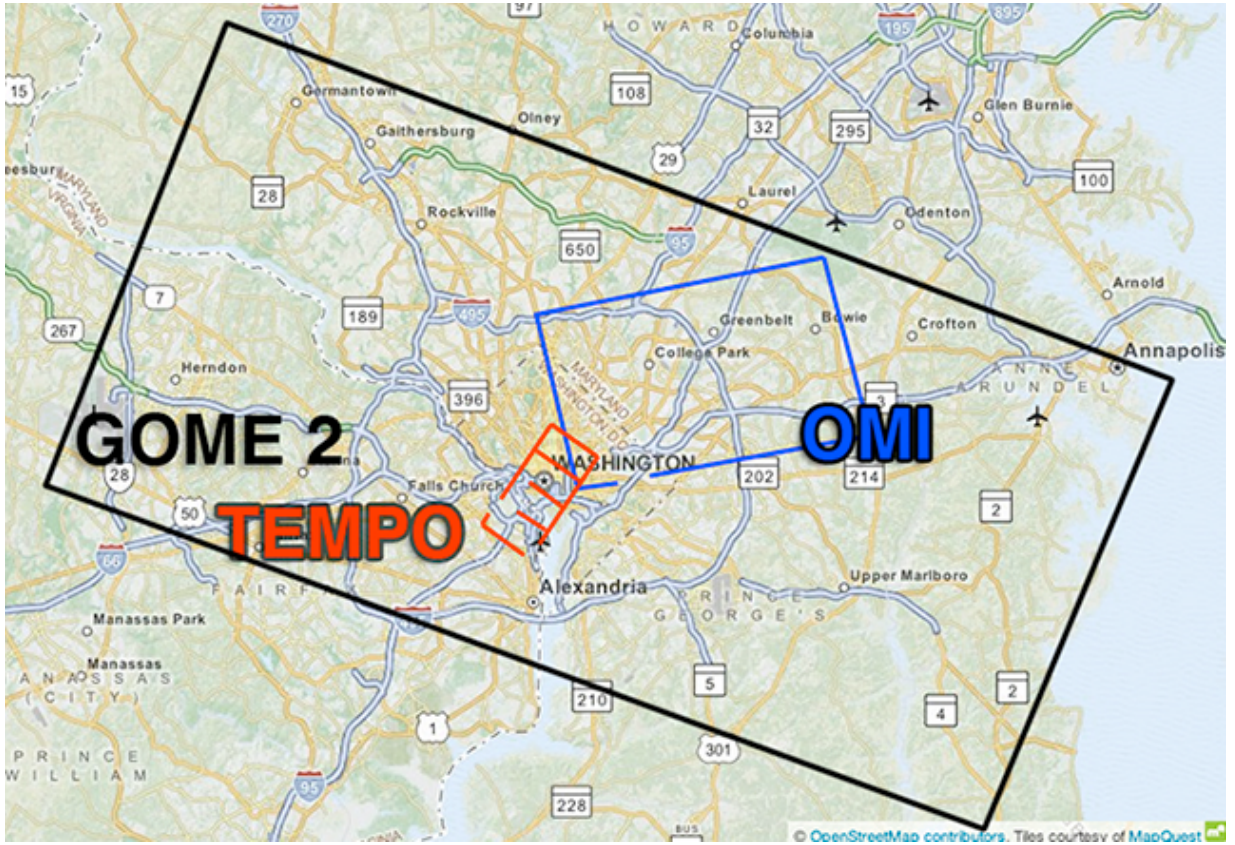
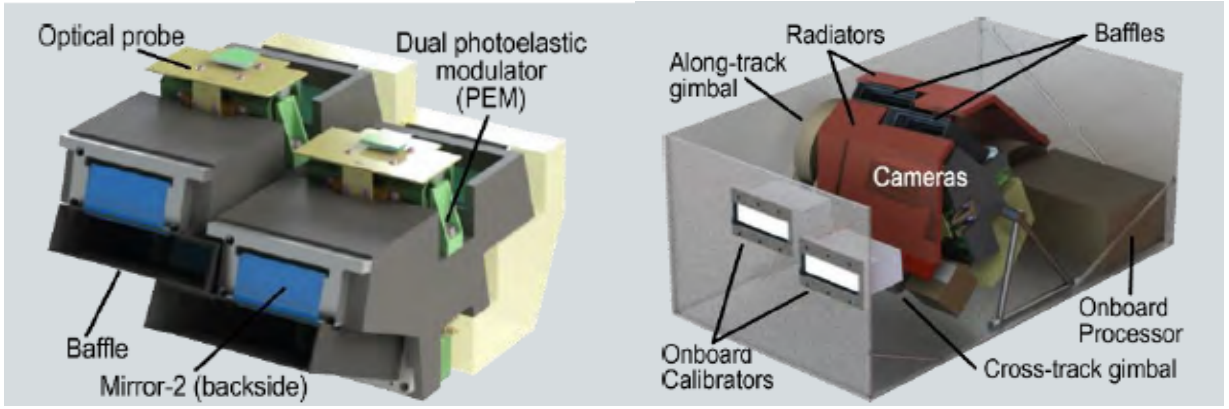
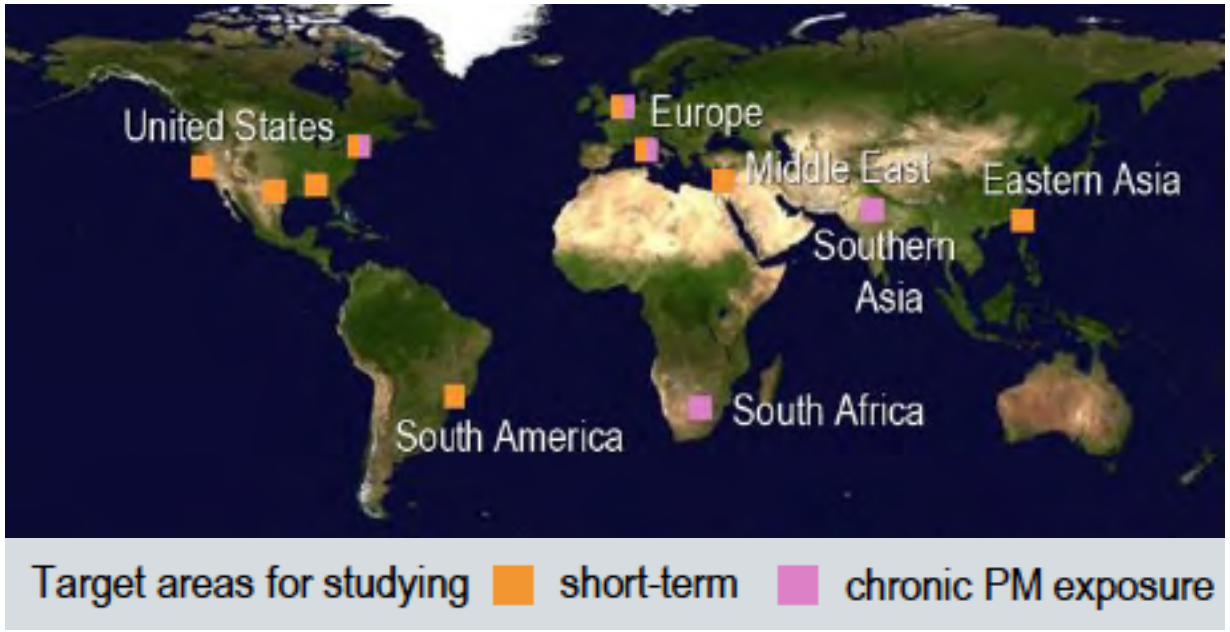


Multi-Angle Imager for Aerosols (MAIA)

- NASA's first health-based mission
- Mission Goal: Assess linkages between different airborne particulate matter types and adverse birth outcomes, cardiovascular and respiratory disease, and premature deaths
- Sun synchronous orbit
- Spatial Resolution: 230 m
- Large Swath Width: 600 km
- Expected Launch: 2021





Multi-Angle Imager for Aerosols (MAIA)

- MAIA measures the radiance and polarization of sunlight scattered by atmospheric aerosols from which the abundance and characteristics of ground-level particulate matter (PM) are derived
- MAIA has the capability to point at a target (i.e., a city) and look at the aerosols from multiple angles to characterize the sizes, compositions, and quantities of particulate matter in air pollution
- MAIA has a MISR-heritage, but can also type aerosols